Effect of Brain-Based Learning Strategies on Span of Attention, Retention and Computational Thinking of Middle-Stage Students

Synopsis

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1.0 Introduction

There has been a paradigm shift in schooling over time. In recent years, the system has undergone substantial changes. From the age of Gurukuls to modern, technologically advanced self-study, we have seen enormous developments. These changes are more intimately tied to the whole concept of education since they are pedagogical in nature. From a teacher-centred to a student-centred strategy, from a knowledge-based to an all-encompassing approach, from a text-based to an information overload, and so forth. The role of the teacher has changed from that of a knowledge transmitter to that of a facilitator, mentor, and motivator. Both the roles and the goals have changed.

Numerous researchers and scholars have significantly contributed to pedagogy. A complex historical hierarchy of educational approaches has developed due to the evolution of pedagogy, which ranges from an emphasis on critical thinking and dialogue to empirical observation, a well-rounded education, and subsequent movements like structuralism, behaviourism, and socio-culturalism, as well as progressive philosophies like psychoanalysis and cognitivism**. (**Eppich, 2021; Ayodele, 2023; Iannone, 2023; Rajpoot, 2016**;** Gupta, 2005; Aggarwal, 2007)

According to NCFSE 2023, The brain is a sophisticated organ made up of numerous cells arranged into specialized regions, including neurons, glial cells, blood vessels, and many more. The constantly shifting patterns of connections between millions of neurons make up how the brain functions. New brain cell connections indicate new information in learning, which is a physical process. Experience, such as a child's possibilities for social and cognitive growth, shapes and is formed by the brain. If the brain is continually challenged and engaged, it may acquire and retain new information throughout life.

1.1 Brain-Based Learning Strategies

In the present era, our education system has shifted from structuralism to cognitive and brain learning. Over time, neurologists and educators came together to enhance students' learning processes by integrating neuroscience and education (Wolfe, 2001; Doyon & Benali, 2005; Posner & Rothbart, 2023). Neuroscientists help to understand how the brain functions (Meningitis Research Foundation, 2018; Northern Brain Injury Association, 2023; Du et al., 2019; Hofman, 2014). Neuro-educationalists use the findings of the brain to enhance the scope of learning (Ozden et al, 2008; Pacheco & Oliveira,

2023).

In the 17th-century philosophy of Descartes, mind-brain connections were explored (Westphal, 2016). In 1986, the experiment was carried out by Ulric Neisser (as cited in Parvin, 2012), regarded as the founder of cognitive psychology, to demonstrate how our recollections of the past are distorted and reshaped in our minds using layered memories rather than real events. Haward Gardner revolutionised intelligence theory in 1993 by defining intelligence as the capacity to solve problems. Additionally, he categorises intelligence into many components, describing each intellect as distinct from the others (as cited in Ghraibeh, 2012).

The term "brain-based learning strategies" refers to instructional strategies, lesson plans, and educational initiatives that are based on the most recent findings in neuroscience about how the brain learns, including aspects like cognitive growth and alterations in learning that occur as pupils become older, develop, and mature on a social, emotional, and cognitive level.

Caine and Caine (1991) applied the findings from structural brain research to the teaching and learning process in the form of pedagogical techniques and learner-centred learning strategies. Caine & Caine (1991) gave the 12 principles for using the concept of Brain-Based Learning (BBL) in the classroom, which are as follows:

1. The brain is a parallel processor.
2. Learning engages the entire physiology.
3. The search for meaning is innate.
4. The search for meaning occurs through "patterning.".
5. Emotions are critical to patterning.
6. Every brain simultaneously perceives and creates parts and wholes.
7. Learning involves both focused attention and peripheral perception
8. Learning always involves conscious and unconscious processes.
9. We have at least two types of memory: a spatial memory system and a set of systems for rote learning.
10. The brain understands and remembers best when facts and skills are embedded in natural spatial memory.

11. Learning is enhanced by challenge and inhibited by threat.
12. Each brain is unique.

These principles of the BBL-based strategies foster a positive learning environment in the classroom. Whereas the entire learning process is geared towards brain empowerment, it includes cognitive, affective, and psychomotor components to show how students learn to perceive, engage with, and respond to learning environments. This aids students in maximising the brain's capacity to think and find information through an active learning process, making student learning more meaningful. (Lidiastuti et al. 2019)

Jensen (2000) suggested some BBL strategies to use in the classroom as pedagogical implementation, such as students having control or accountability, changing the position of the learner, chunking, and brain breaks

In this study, BBL refers to brain-based learning strategies guided by the above principles. These principles are based on an understanding of neuroscience, including how the brain is organised and operates and how it may function more effectively. In this study, the focus will be on computational thinking ability, span of attention, and retention to identify and study the effect of BBL strategies on these variables in learners.

1.2 Span of Attention

According to the seventh BBL principle stated by Caine and Caine (1991), Learning requires focused attention and peripheral perception. Focused attention is the concentration of a person's consciousness on a specific activity, task, or event. The span of attention is a part of focused attention that focuses on multiple pieces of information or stimuli in a single glance or specific period of time, demonstrating the critical role that attention plays in acquiring knowledge. Every branch of psychology touches on the subject of attention. Additionally, the topic of attention is more important due to constantly rising information demands. A significant portion of modern cognitive psychology, cognitive neuroscience, and several other subfields of psychology deal with the subject of attention (Proctor et al., 2023).

In 1754, Leibniz, a mathematician and psychologist, emphasized a reflexive view of attention, according to which attention is spontaneously directed to situations and concepts that call for it. He aimed to base psychology and other sciences on mathematics, a goal shared by contemporary

attention-based quantitative modellers (as cited in American Psychological Association, 2023). William James defined attention in 1890 as the ability to concentrate on any object or engage in any mental activity without becoming deterred by an outside influence (James, 1890). Attention is meant when a learner actively processes a limited amount of information from the enormous amount of information available through our senses, our stored memories, and other cognitive processes (as cited in Sternberg, 2007, p. 56).

One of the components of attention is the span of attention, which is the capacity to comprehend many stimuli at once. Attention has been studied in conjunction with many other topics in neuroscience and psychology, including awareness, vigilance, saliency, executive control, and learning (Lindsay, 2020). Attention is the process that forces people to choose a certain stimulus from a variety of environmental stimuli based on their interests and attitudes. Therefore, to put it briefly, it is the selective action of consciousness as a process of bringing a thought object clearly before the mind.

The span of attention truly reveals how many things may be in a person's conscious awareness at a given time. The quantity of things that can be understood in a brief presentation is referred to as the Span of Attention. The first experimental investigation on this topic was conducted by Sir William Hamilton in 1859. Significant facts were later revealed by ongoing serial research. Sir William Hamilton (1859) said in his experiment that we can increase the span of attention by chunking the information (as cited in Oyama, 1986).

Span of attention facilitates the ability to take in a variety of events and pieces of information at a time, which is beneficial for the student's learning abilities. To offer a neuropsychological foundation for the span of attention and to identify proposed strategies by neuropsychologists that increase the span of attention, the present study focuses on the span of attention by employing the brain functioning principle of BBL. which strategies will be applied during the intervention period to gauge how well it is performing.

1.3 Retention

The retention of information that has been learned may be described as being stored in long-term memory in a way that makes it possible to quickly recover it, for instance, in response to common cues (Bennett & Rebello, 2012). Retention is crucial to a student's learning process because, as stated in the

BBL ninth and tenth principles by Caine & Caine (1991), We have at least two types of memory: a spatial memory system and a set of systems for rote learning." and "The brain understands and remembers best when facts and skills are embedded in natural spatial memory.". The importance of memory retention for learners' academic success cannot be overstated (Irene et al., 2020). According to Gains (2001), the transfer of information depends on retention, as much of the teacher's time will be spent on review and reteaching if pupils fail to recall prior knowledge (Toheed et al. 2017). According to Filgona and Sababa (2017), The capacity of the pupils to grasp the knowledge they have learned about a certain subject is known as retention of taught content. They go on to state that learners demonstrate retention by doing well on the assessments designed to gauge their achievement.

Houston (2001) examined the theoretical and experimental psychology research that lays the foundation for human learning and memory. As described by Houston as "a relatively permanent change in potentiality that occurs as a result of reinforced practice," retention processes cannot be isolated from the acquisition and transfer elements of the complete learning process (cited in Sanatullova-Allison, 2014).

The study of retention clearly overlaps with the study of memory but differs in that for information to be viewed as retained, students must be able to recall it when appropriate in response to prompts such as those usually found in schools and not merely in response to experiential cues, such as the smell of freshly baked bread (Bennett & Rebello, 2012).

Memory retention is of utmost importance to pupils' academic success. The pupils with memory issues could have trouble recalling class lessons. Additionally, they could struggle with multi-step mathematical tasks. They need to recall arithmetic knowledge from long-term memory while also recalling what they recently finished and what they need to do to answer those issues (Pillado et al., 2020). The abundance of research in this area that concentrates on the teaching and learning process attests to the significance of students' memory retention (Pantziara & Philippou, 2014**).**

Retention is a crucial component of learning that displays all of a student's learning abilities, including academic success, memory, power recognition, classroom performance, etc. In this study, an attempt will be made to find pedagogical strategies that enhance student retention. The present study will use the foundation of neuroscience, or brain functioning information, to improve the retention capacity of

students. By using the ninth and tenth principles of BBL. We have at least two types of memory: ‘a spatial memory system and a set of systems for rote learning, and the brain understands and remembers best when facts and skills are embedded in natural spatial memory’ to determine the strategies from renowned scholars in this field that will be used in the intervention period of this study on middle-stage students.

1.4 Computational Thinking

Due to the differences in definitions among academics, the Present study will take into account both the definitions established by the academics themselves as well as those supplied by organisations like the International Society for Technology in Education (ISTE) and the Computer Science Teacher Association (CSTA) (Cansu & Cansu, 2019).

ISTE (2023) defines computational thinking as educators continually improving their practice by developing an understanding of computational thinking and its application as a cross-curricular skill. Educators develop a working knowledge of the core components of computational thinking, such as decomposition, gathering and analysing data, abstraction, algorithm design, and how computing impacts people and society. CSTA defined computational thinking (CT) as practices that intersect with creative, collaborative human activities. This has led to some really interesting explorations in computing, cognition, and culture (as cited in Lee 2023).

A crucial component of computational thinking is pattern recognition, which is consistent with the notion that learners look for meaning in patterns to be identified. Similar to "The search for meaning occurs through patterning," this is the fourth of Caine and Caine's BBL principles from 1991, and it is a method for teaching people how to comprehend information by identifying, then following patterns, and utilizing it as a method for solving problems. Not just for computer scientists, but for everyone, Computational thinking is a fundamental ability. Every child's analytical skill should include computational thinking in addition to reading, writing, and maths. (Wing, 2006).

The phrase "thinking as a computer scientist" (also known as "computational thinking" or "CT") refers to the capacity to develop and resolve issues using computer science principles. In recent years, computational thinking has been marketed as a competency or talent that is just as vital as literacy and maths. (EU Science Hub, N.D.). The notion of computational thinking differs from researcher to

researcher because the discipline is still in its infancy. According to Hemmendinger (2010**),** "Computational Thinking is to educate students on how to think like an economist, a physicist, or an artist and to comprehend how to utilise computing to solve their issues, develop new things, and find new subjects that can be thoroughly investigated." (as cited in Cansu & Cansu, 2019).

In order to create solutions that are as effective as possible, computational thinking trains students to think like computer programs. Computational thinking employs parallel processing, recursive problem-solving, abstraction, and decomposition Wing 2006 when tackling a huge, complicated task Computational thinking emphasises cooperation and student-centred interaction while also assisting students in realising that some activities that initially appear to be very tough are actually very feasible. (Clarity Innovations, Inc., 2019).

Computational thinking is important for students because it helps them solve problems logically and create critical thought patterns. In this study, the researcher intends to help students develop this skill by fusing educational methods with knowledge of the brain's biology. The use of the BBL's fourth principle in this research's quest for efficient pedagogical strategies that will boost middle-stage students' computational thinking skills.

2. Emergence

In the present scenario, the learners are facing difficulties in focusing and concentrating on the learning process, as well as memory and retention issues that limit their capacity for problem-solving, critical thinking, reasoning, and analysis abilities. It has an impact on their performance, creativity, and focused learning. Numerous groups, committees, and policies are attempting to improve these aspects of the teaching-learning process.

According to NCFSE 2023, there is a critical role for the brain in students' learning processes; hence, various brain-based teaching methods and tactics should be used to improve student learning (p. 100). Caine & Caine (1991) gave 12 principles of brain-based learning to integrate neuroscience with the learning of students. These principles accumulate the various strategies to be followed. There is numerous research that supports the idea that BBL strategies can enhance the learning of students. (Ramakrishnan, 2013; Jensen, 2000, 2005; Lombardi, 2022; Freeman & Wash, 2013).

Attention has many facets and is broken down into different types. One type is the span of attention,

which refers to the capacity to incorporate multiple events or pieces of information into a single gaze. This type of span of attention is used in education to assess a student's level of awareness and how much they can concentrate on learning from various events or pieces of information at the same time. This degree of importance prompted the researcher to investigate whether introducing BBL methods into the instructional strategy may increase middle-stage students' span of attention.

Although there is no concrete evidence to support the claim that increasing student involvement in class will increase their span of attention, Eric Jensen (2000) suggests some strategies in Brain-Based Learning 2000. These include giving students more control or accountability, changing the position of the learner, encouraging the role of the learner, collaborative learning, Spaced Repetition, using mnemonics to teach others, etc.

The retention of mathematical ideas is a key component of NCFSE 2023; as a result, multiple instructional techniques should be used to improve middle stage students' comprehension and retention (p. 194). According to Ritter (2013)**,** retention is crucial to the transfer of learning and how well students acquire and transfer knowledge. This present study hopes to shed light on how to better incorporate brain-based learning principles into classroom instruction to help middle-stage pupils retain concepts and knowledge.

The ability to retain information is useful in every step of the problem-solving process, including pattern recognition, abstraction, decomposition, and algorithm development. The brain-based learning strategies for memory and retention, as listed by Jensen (2000) Brain-based Learning strategies include role-playing, at-home assignments, related music, and discussion game simulations; however, no research has been found to support these strategies to improve students' retention.

NCFSE 2023 considers computational thinking to be an important aspect, as it is considered a curriculum goal to integrate it into the teaching method for the enhancement of the learning process, problem-solving ability, and critical thinking skills. Computational thinking is emphasised, as mentioned in the curriculum goal for middle-stage students in NCFSE 2023, because it has grown to be a fundamental talent that teachers should work to instil in their students. (p.185) According to NEP 2020, mathematical abilities should be integrated and improved with the use of computational thinking. As NEP 2020 focuses on integrating computational thinking to boost the capacity to learn

mathematics in students (p. 15).

According to Diani et al. 's (2023) investigation of how BBL influences students' problem-solving skills, the BBL model was successful in enhancing these skills. From a pedagogical standpoint, the careful application of computational tools and skill sets can enhance students' understanding of mathematics and scientific content. It also attempts to develop the essential mathematical skills of pattern recognition, hypothesis generation, and explanation generation through creative problem-solving, computational thinking, and logical communication. NCFSE 2023 and NEP2020.

To promote computational thinking (CT) as a 21st-century competency among primary to secondary students, Tabesh (2017) conducted an analysis study of educational approaches to developing computational thinking. This aims to provide a thorough overview of recent research findings, grassroots initiatives, and policy initiatives. In light of the importance of computational thinking, present research will be done in this area. Few studies have investigated the connection between computational thinking skills and BBL (Ashiqin Ali & Yahaya, 2021) Additionally, the researcher did not come across any comparable studies on middle stage students.

3. Justification

The teaching process has become more student-centred in recent times. There are many different techniques to instruct and improve learners. NCFSE 2023 and NEP 2020 have placed a strong focus on brain function and see the brain as a key component of learning processes. Eric Jensen's (2000 and 2008) work on the BBL principle and his recommendations for teaching and learning strategies advocate that teaching methods should be synthesised with the strategies to make them by focusing on each principle of the BBL. The present study will use various strategies for teaching during the intervention period that help improve the brain capacity of students and enhance learning. This study will show how brain-based learning strategies improve student learning and provide a foundation for discussing how successful teaching is when BBL principles are applied in classroom interaction.

According to the seventh principle of BBL, learning necessitates focused attention to retain the information. The attention spans of the students allow them to be aware and ready to accept the knowledge while also being focused on taking in a lot of critical information at once. By utilizing the various tactics based on BBL principles, this study will assist in determining if BBL strategies

improve the span of attention in middle-stage students.

Retention is the focus point to absorb knowledge in its long-term form and remember it readily when it is needed, as well as to lay the foundation for higher performance in the class. Attention aids in memory for a long time. This study will focus on BBL strategies that support increasing middle-stage students' retention capacity.

Computational thinking is one of the 21st-century skills that is a component of problem-solving (Haseski et al., 2018). The ability to solve issues is the most crucial talent to employ in the educational system to perform better during the teaching and learning process. The CT is focused on the BBL concept of the crucial patterning of meaning. This work contributes to the development of methods for enhancing computational thinking.

Here, the study will help lay the groundwork for what kinds of techniques and strategies are necessary to help students pay attention for longer periods, as well as how they can incorporate and process information when it needs to be retained. It will also give students insight into how to improve their computational thinking, which is regarded as a problem-solving skill that involves thinking like a computer or computer scientist.

This study will cover the effect of BBL strategies on middle-stage pupils' span of attention retention and computational thinking. These factors are all crucial for the operation of the educational system and will be the basis for improving the level of BBL strategies, which will also increase the learning capacity of middle-stage students.

4. Research Question

1. Is there any effect of Brain-Based learning strategies on the span of attention of Middle-Stage students?
2. Is there any effect of Brain-Based learning strategies on the retention of Middle-Stage students?
3. Is there any effect of Brain-Based learning strategies on the computational thinking of Middle-Stage students?

5. Statement of the Problem

Effect of Brain-Based Learning strategies on the Span of Attention, Retention, and Computational Thinking of Middle-Stage Students.

6.0 Defining the Terms

6.1 Brain-Based Learning Strategies

BBL is an enriched learning environment that enables the brain to learn in a natural way while at the same time allowing each student to be involved in the learning process in her or his own way. (Caine & Caine, 1991).

Brain-based learning strategies are practices that make use of our understanding of how the brain works to improve the efficacy of learning. These strategies are used by educators to customize lessons, take advantage of cognitive processes, and design learning environments that maximize students' prospects for success in the classroom. Teachers strive to enhance learning outcomes for all children by implementing neuroscience-based ideas. (Ramakrishnan et al., 2013)

Operational Definition: In this study, the term "Brain-based learning strategies" is defined as the application of neuropsychological knowledge of the brain to create principles that may be applied to classroom instruction to enhance student's capacity to concentrate, remember information, and solve problems.

6.2 Span of Attention

The Span of attention refers to the number of independent, distinct or separate stimuli that can be attended to by an individual at a glance in a very brief period of time (Srinivasan, 2017).

Operational Definition: In this study, the term "Span of Attention" is described as the number of objects that can be grasped in one short presentation by an individual. The effect on span of attention will be measured by comparing the post-performance scores of the experimental and control groups.

6.3 Retention

“Retention of learned information can be defined as having the information stored in long-term memory in such a way that it can be readily retrieved, for example, in response to standard prompts”. (Bennett & Rebello, 2012).

Operational Definition: in this study, the term "retention" is used to mean recalling or retaining for a long period of time the concepts that were taught in the intervention period of this study; The effect on retention will be measured by the comparison of the post-test scores of the experimental and control groups.

6.4 Computational Thinking

Computational thinking is the thought process involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry it out (Wing, 2006).

Operations Definition: In the present study, computational thinking is considered to involve breaking down a problem into manageable steps like decomposition, pattern recognition, pattern abstraction, and algorithm. Plan how students will interpret the issue and how it will be resolved by breaking it up into manageable pieces or by having them "think like a computer." The effect on computational thinking will be measured by comparing the post-test scores of the experimental and control groups.

6.5 Middle-Stage Students

In this present study, middle-stage students are stated or used as students who are enrolled in the middle-stage period of 6 to 8, according to NEP 2020. In this study, 8th grade students will be used for the treatment and control groups. The age group mentioned in NEP 2020 for middle-stage students is 11 to 14 years old.

The NCFSE 2023 emphasises the importance of integrating computational thinking with mathematics education as it aligns with Jean Piaget's stages of cognitive development. According to Piaget, children normally begin the formal operational stage when they are eleven or twelve years old. The brain begins to interpret information through logical and abstract analysis at this crucial point. At this level, students learn to understand theories, absorb abstract ideas, and come up with possible answers to hypothetical issues (as cited in (Lourenço, 2014)). As a result, including computational thinking at this stage improves logical reasoning and gets pupils ready to approach difficult problems methodically.

7. Objectives

- To investigate the span of attention of middle-stage students
- To investigate the retention level of middle-stage students
- To investigate the level of computational thinking in middle-stage students
- To find the effect of brain-based learning strategies on the span of attention of middle-stage students
- To find the effect of brain-based learning strategies on the level of retention of middle-stage

students

- To find the effect of brain-based learning strategies on the computational thinking of middle-stage students

8. Hypothesis

- There will be a significant effect of brain-based learning strategies on the span of attention of middle-stage students
- There will be a significant effect of brain-based learning strategies on the retention of middle-stage students
- There will be a significant effect of brain-based learning strategies on the computational thinking of middle-stage students

9. Delimitation of Study

- The study will be delimited to Agra City
- The study will be delimited to VIII-class students
- The study will be delimited to the mathematics subject.

10. Variables of the Study

- **Independent variable:** Brain-based learning strategies
- **Dependent Variables:** Span of Attention, Retention and Computational Thinking
- **Controlled Variables:** Age, Class, Gender, School, and Learning Environment

These variables will be controlled using different methods, as mentioned in table 1.

Table 1 *Method of Controlling Variables*

Controlled variable	**Method of controlling variable**
Temperature, place to sit	Holding a variable constant
Characteristics of learners like IQ performance level interest, age, gender, etc	Randomization,
Time schedule for teaching controlled group and experimental group in reversible form	manipulating the situational variable

11. Research Method and Design

Research Method: For this study, the experimental method will be used, in which two groups—

experimental and control—will be selected to compare the effects of treatment with those of no treatment during the study's intervention period. According to Kaul (1996), "An experimental research method entails comparing the effects of a certain therapy with those of a different treatment or of no treatment. Typically, an experimental group and a control group are mentioned in a straightforward conventional experiment (p. 135).

Research Design: This study will use a Control Group Pretest-Post-test design of a true experimental design in which two groups, the active control group and the experimental group, will be selected by randomization. Both groups will take a pre-test prior to the intervention. The experimental group will be taught using BBL strategies during the intervention period, while the active control group will be taught using traditional teaching methods. After the intervention period, post-tests will be taken from both groups and compared to determine the level of significance.

According to Kaul (1996), true experimental designs are mostly used for experimental research in education because they seek to control the main effects of history, maturation, testing, measuring, instruments, statistical regression selection, and mortality" (p. 463). True experimental design is the most effective in minimising threats to experimental validity. One type of this design is Randomised Control Group Pretest-Post-test design (Best & Kahn, 1996, p. 148), which is being used for this study.

The design of the present study is mentioned in table 2:

Table 2 *Research Design*

Research Method	**Groups**	**Pre-Test**	**Interventions**	**Post-Test**
True Experimental Method	Experimental Group (randomly assign 40 students)	Pre-test- Performance task for Span of attention, computational thinking Test for retention	Teaching Mathematics: A 30-Lesson Plan Using BBL strategies	Post-test- Performance task for Span of attention, computational thinking Test for retention
	Active Control Group (randomly assign 40 students)	Pre-test- Performance task for Span of attention, computational thinking Test for retention	Teaching Mathematics: A 30-Lesson Plan using traditional methods	Post-test- Performance task for Span of attention, computational thinking Test for retention

12. Sample of the Study

The population targeted for the study is the middle-stage students of Agra. A CBSE school in Agra will be selected as a purposive sample. 80 middle stage students will be selected through random sampling from the school. This study will use the Multi-level Mix method of sampling for a two groups design experimental study. Rosenshine & Stevens (1986), as cited in Teddlie & Yu (2007), defined a multilevel mixed-method sampling strategy with purposive sampling at the school level and probability sampling at the classroom level. Students will be divided into two groups: one is an active control group, which will be taught with traditional teaching pedagogies, and the other is an experimental group, which will be taught using BBL strategies. In this study, the sample design is mentioned in fig. 1.

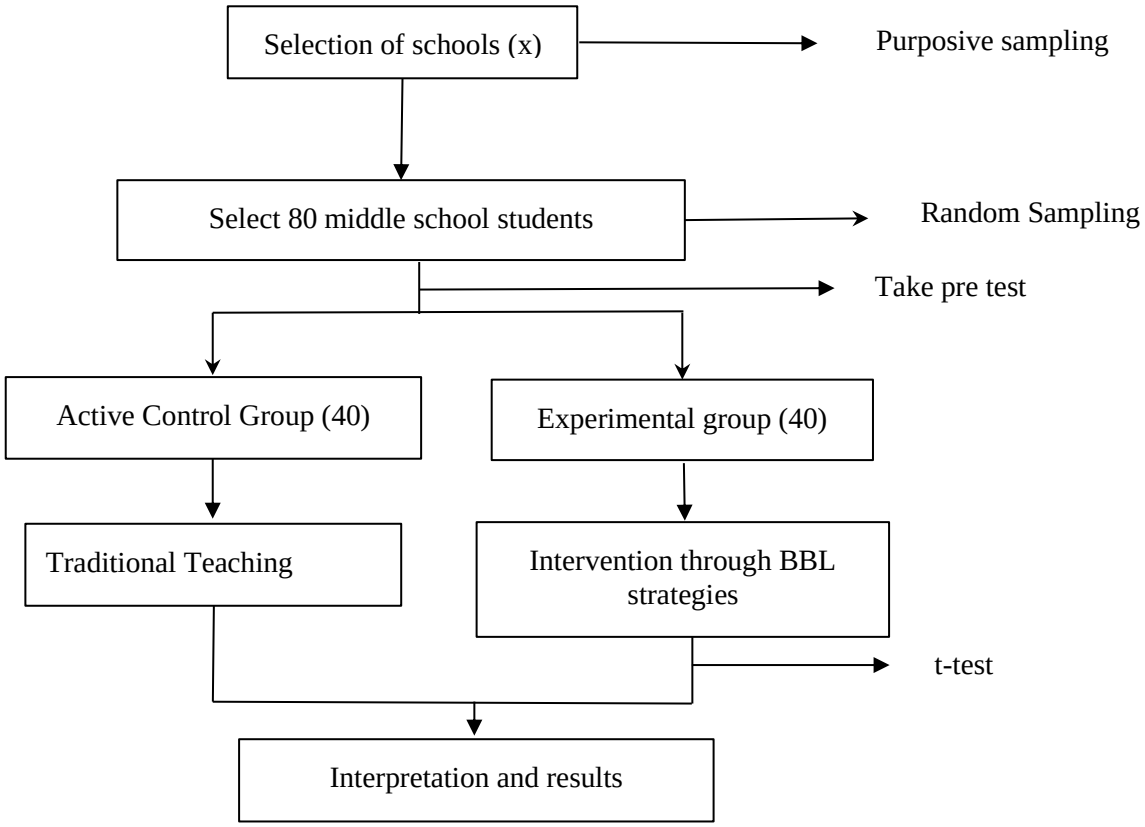

Fig. 1 ***Sample Design***

13. Tools for the Study

13.1 Span of Attention

Table 3 illustrates the tests and performance tasks that were surveyed by the researcher in this study to determine the span of attention of middle school students.

Table 3 ***Rationale of tool selection to measure span of attention***

Name of test	Author	Status	Reason
Digit Span Test:	David Wechsler 1945	Rejected	This can be used for the test attention span and working memory
Letter-Number Sequencing	David Wechsler, 1955.	Rejected	This can be used for the test attention span
N-Back Task	Wayne Kirchner, 1958	Rejected	Not accessible due to technical issue
Tachistoscope: Falling door type model	Dr Vivek Bhargava	Selected	This tool is used in experiments concerned with visual perception, recognition speed, and memory, which is according to the requirements of the study.

As can be seen, the tachistoscope satisfies the need of the current study to measure the span of attention. A tachistoscope will be used in this study.

13.1.1 Tachistoscope: Falling door type model by Dr Vivek Bhargava

A performance task will be conducted to measure the span of attention of students. A Tachistoscope is an apparatus designed to expose objects for a brief period of time. A subject is given a momentary glance from 1/5th to 1/10th of a second at regular or irregular groups of dots or letters and must tell how many he has observed. To determine the span of attention for the following types of visual stimuli:

1. Single dots
2. Grouped dots
3. Nonsense Syllables (meaningless combinations of letters)
4. Meaningful words,

13.2 Computational Thinking

In the present study, some tests and scales were surveyed to assess computational thinking. Some of them are mentioned in table 4.

Table 4 ***Rationale of tool selection to measure computational thinking***

S. No.	Name of Tool	Authors	Year	Status	Reason
1	Computational Thinking	Buket Ertugrul-	2019	Rejected	This test focuses on university- level teachers and emphasises other

	Scale (CTS)	Akyol			dimensions, including CT
2	Computational Thinking Scale	Joseph Guggemos	2021	Rejected	This scale is rejected because it does not seem feasible, and reliability and validity are also not credible.
3	Pac-Man Patterns: Ghost Movement	Joseph Guggemos	2021	Rejected	This performance is subjective in nature, and reliability and validity are provided.

As observed, there is no tool that seems perfect for the study to assess the computational thinking of middle stage students. So, the researcher decides to construct a tool to assess computational thinking.

13.2.1 Self-constructed test for computational thinking for middle-stage students

Computational thinking is defined as breaking down a problem into smaller pieces, recognizing patterns, and eliminating extraneous details so that the step-by-step solution can be replicated by humans. A test will be constructed by the researcher by using the dimensions of computational thinking that were previously discussed in various studies, which are as follows:

1. Decomposition To solve a complex problem, one must first break it down into smaller, more manageable parts.
2. Pattern recognition: it is the process of identifying patterns or connections between different parts of a bigger problem.
3. Abstraction: it is the process of determining what needs to be done specifically to solve each decomposed problem or generalising the most relevant data from each decomposed problem.
4. Algorithmic thinking: it is the process of defining a step-by-step solution to a problem that can be replicated for a predictable and reliable outcome.

13.3 Retention

In the present research, the researcher reviewed different tests and scales to determine how well middle-stage students could retain information. Few of them are mentioned in table 5.

Table 5 ***Rationale of tool selection to measure retention***

S. No.	Name of tool	Author	Year	Status	Reason
1	Choynowski's Memory Scale	Mieczysław Choynowski	1959	Rejected	Not accessibility and can not generalise in this study

2	Memory Assessment Scales	J. Michael Williams	1991	Rejected	Old and not fulfil the need of the Study
3	Science Retention Test	Manisha	2020	Rejected	This study uses the science content only and focuses on the science subject

It has been observed that there are no tests or scales that meet the current requirements for this study. Therefore, the researcher chooses to develop a test to evaluate middle-stage students' retention. The achievement exam that the researcher will create for the pretest to evaluate retention level before the intervention. Additionally, the researcher will create a retention test for the post-test and compare the post-test results of the experimental and control groups to determine the level of retention.

13.3.1 Self-constructed achievement test (pre-test)

An achievement test will be constructed by the researcher to assess the retention of previous knowledge by students based on the previously covered syllabus.

According to Filgona and Sababa (2017), retention of taught content refers to a student's ability to retain what they have learned about a certain subject. According to this theory, students show retention by performing well on the tests meant to measure their achievement.

13.3.2 A Self-constructed Test for Retention of Middle-Stage Students: Post-Test

The researcher will construct a post-test to assess the level of retention on the basis of the intervention provided by using BBL strategies with the middle-stage students.

14. Statistical Methods

Descriptive Statistical analysis will be conducted using Mean, Median, Mode, Standard deviation, and percentage analysis.

For inferential Statistical analysis: use parametric statistics (T-test and ANCOVA).

Bibliography

Aggarwal, S. (2007). *Philosophical foundations of education* (1st ed., Vol. 1). Authorspress.

Ayodele, E. (2023). The relevance of philosophy of socrates to modern philosophy of research. *Journal of Social and Humanities Studies*. https://doi.org/10.56388/jshs230716

American Psychological Association. (2023). Attention. *American Psychological Association.*

https://www.apa.org/pubs/books/attention

Ashiqin Ali, W. A. W. A. N., & Yahaya , W. A. J. W. (2021). A systematic review of studies of parental involvement in Computational Thinking Education. *Journal of Human Development and Communication*, *9*, 11–22.https://www.researchgate.net/publication/349074436_A_Systematic_Review_of_Learning_Theory_on_Computational_Thinking

Bennett, A.G., & Rebello, N.S. (2012). Retention and Learning. In: Seel, N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA. https://doi.org/10.1007/978-1-4419-1428-6_664

Best, J. W., & Kahn, J. V. (1996). *Research in education* (7th ed., Vol. 10). Prentice-Hall of India

Brain structure and function: Brain injury: British Columbia. Northern Brain Injury Association

British Columbia. (2017, January 31). https://www.nbia.ca/brain-structure-function/

Caine, R. N., & Caine, G. (1991). *Making connections teaching and the human brain*. Distributed by ERIC Clearinghouse. https://files.eric.ed.gov/fulltext/ED335141.pdf

Caine, R. N., & Caine, G. (1991). *Making connections teaching and the human brain* (1st ed., Vol. 1, Ser. 11-91025). Distributed by ERIC Clearinghouse. https://files.eric.ed.gov/fulltext/ED335141.pdf

Cansu, F. K., & Cansu, S. K. (2019, April). An overview of computational thinking. *International Journal of Computer Science Education in Schools*, *3*(1), 17–30. https://www.ijcses.org/index.php/ijcses/article/view/53

Caruso, G. (n.d.). *ITD*. CNR. https://www.itd.cnr.it/en/research/projects/computhink.html

Chinwendu. (2023, April). Effectiveness of using observational method to teach a course in psychology. https://www.researchgate.net/publication/369907165_EFFECTIVENESS_OF_USING_OBSERVATIONAL_METHOD_TO_TEACH_A_COURSE_IN_PSYCHOLOGY

Clearityity Innovations, Inc. (2019). What is computational thinking? - K-12 blueprint. https://www.k12blueprint.com/sites/default/files/Computational_Thinking_Definition.pdf

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education*. Routledge.

Copyright American Psychological Association. (2023). https://www.apa.org/pubs/books/attention-sample-pages.pdf

Coulacoglou, C., & Saklofske, D. H. (2017). Executive function, theory of mind, and Adaptive Behavior. *Psychometrics and Psychological Assessment*, 91–130. https://doi.org/10.1016/b978-0-12-802219-1.00005-5

Crocker, J., & Wolfe, C. T. (2001). Contingencies of self-worth. *Psychological Review*, *108*(3), 593–623. https://doi.org/10.1037/0033-295x.108.3.593

Diani, R., Octafiona, E., Satiarti, R. B., Wiliyanti, V., & Janah, M. H. (2023). Physics learning with brain-based learning (BBL) model and Savir Approach: The effects on students' problem-solving ability. *IWOSP 2021, INTERNATIONAL WORKSHOP ON STATISTICAL PHYSICS*. https://doi.org/10.1063/5.0123734

Doyon, J., & Benali, H. (2005). Reorganization and plasticity in the adult brain during learning of motor skills. *Current Opinion in Neurobiology*, *15*(2), 161–167. https://doi.org/10.1016/j.conb.2005.03.004

Du, W., Li, S., & Wang, Z. (2019). Research on the human brain, the external brain and the public external brain. *Journal of Physics: Conference Series*, *1168*, 032053. https://doi.org/10.1088/1742-6596/1168/3/032053

Eppich, R. (2021). Perspectives on pandemic: Pedagogies, prejudice and a paradigm shift. *Journal of Research in Architecture and Planning*, *31*(2), 01–11. https://doi.org/10.53700/jrap3122021_1

EU Science Hub(n.d.). *The computational thinking study*. European commission. . https://joint-research-centre.ec.europa.eu/computational-thinking-study_en

Ertugrul-Akyol, B. (2019). Development of Computational Thinking Scale: Validity and Reliability Study. *International Journal of Educational Methodology*, *5*(3), 421–432. https://doi.org/10.12973/ijem.5.3.421

Filgona, J; & Sababa, L., K. (2017). *Mastery Learning Strategy and Learning Retention: Effects on Senior Secondary School Students; Achievement in Physical Geography*

in Ganye Educational Zone, Nigeria. https://doi.org/10.20944/preprints201702.0018.v1

Freeman, G. G., & Wash, P. D. (2012, November 30). *You can lead students to the classroom, and you can make them think: Ten brain-based strategies for college teaching and learning success*. Journal on Excellence in College Teaching. https://eric.ed.gov/?id=EJ1026152

Gains, M. (2001). What Factors Effect Retention in the Classroom?. Retrieved on July 5, 2017 from::https://gse.gmu.edu/assets/docs/lmtip/vol3/M.Gaines.doc

Ghraibeh, A. M. (2012). Brain Based Learning and its relation with multiple intelligences. *International Journal of Psychological Studies*, *4*(1). https://doi.org/10.5539/ijps.v4n1p103

Guggemos, J., Seufert, S., & Román-González, M. (2022). Computational thinking assessment – towards more vivid interpretations. *Technology, Knowledge and Learning*, *28*(2), 539–568. https://doi.org/10.1007/s10758-021-09587-2

Gupta, S. (2005). *Education in emerging India: teachers' role in society* (1st ed., Vol. 1). Shipra

Haseski, H. I., Ilic, U., & Tugtekin, U. (2018). Defining a new 21st-century skill-computational thinking: Concepts and trends. International Education Studies, 11(4), 29. https://doi.org/10.5539/ies.v11n4p29

Hofman, M. A. (2014). Evolution of the human brain: When bigger is better. *Frontiers in Neuroanatomy*, *8*. https://doi.org/10.3389/fnana.2014.00015

Iannone, A. P. (2023). Teaching Philosophy: Finding a Balance between the Factors that Motivate Philosophy, Students' Imagination, and their Interests. SATS, 24(1), 93–110. https://doi.org/10.1515/sats-2023-0006

ISTE Computational Thinking Competencies. ISTE. (2023). https://www.iste.org/standards/iste-standards-for-computational-thinking

Janowski, K., Gustaw, K., & Kasprowicz, M. (2012, February 29). Application of Choynowski's Memory Scale in the assessment of patients with dementia. Archives of medical science : AMS. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3309449/

Jensen, E. (2008). Teaching with the Brain in Mind (2nd ed.). ASCD. https://www.researchgate.net/publication/314967156_John_Dewey_and_His_Philosophy_of_Education

Jensen, E. (2000). *Brain-based learning: the new science of teaching & training* (1st ed., Vol. 1). Pearson Education.

Kim, R. E., Lee, M., Kang, D. W., Wang, S.-M., Kim, D., & Lim, H. K. (2023). Effects of education mediated by Brain Size on regional brain volume in adults. *Psychiatry Research: Neuroimaging*, *330*, 111600. https://doi.org/10.1016/j.pscychresns.2023.111600

Koul, L. (1996). *Methodology of educational research*. Vikas Pub. House.

Lagoudakis, N., Vlachos, F., Christidou, V., & Vavougios, D. (2022). The effectiveness of a teaching approach using brain-based learning elements on students' performance in a Biology course. *Cogent Education*, *9*(1). https://doi.org/10.1080/2331186x.2022.2158672

Lourenço, O. M. (2014). Piaget, Jean. *ResearchGate*. https://www.researchgate.net/publication/282705581_Piaget_Jean

Lee, M. G. (2023, June 20). *Teaching Computational Thinking in Early Elementary*. Computer Science Teachers Association. https://csteachers.org/teaching-computational-thinking-in-early-elementary/

Levin, E., Bernier, J. (2011). Attention Span. In: Goldstein, S., Naglieri, J.A. (eds) Encyclopedia of Child Behavior and Development. Springer, Boston, MA. https://doi.org/10.1007/978-0-387-79061-9_226

Lidiastuti, A. L., Prihatin, J., & Iqbal, M. (2019). The development of EXAIR (example auditory thinking repetition) learning model based on BBL (brain-based learning) and its effect on problem-solving capability on secondary schools in the Coastal Area. *IOP Conference Series: Earth and Environmental Science*, *243*, 012094. https://doi.org/10.1088/1755-1315/243/1/012094

Lindsay, G. W. (2020). Attention in psychology, neuroscience, and Machine Learning. *Frontiers in Computational Neuroscience*, *14*. https://doi.org/10.3389/fncom.2020.00029

Lombardi, J. (2008). Beyond learning styles: Brain-based research and English language learners. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *81*(5), 219–222. https://doi.org/10.3200/tchs.81.5.219-222

MRF Meningitis Symposium 2018. Meningitis Research Foundation. (2018).

https://www.meningitis.org/healthcare-professionals/conferences-and-symposia/mrf-meningitis-symposium-2018-(1)

National education policy 2020 - Ministry of Education. (2020). https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English.pdf

Oyama, T. (1986). The effect of stimulus organization on numerosity discrimination. *Japanese Psychological Research*, *28*(2), 77–86. https://doi.org/10.4992/psycholres1954.28.77

Ozden, M. (2015, November 6). *The effects of brain-based learning on academic achievement and retention of knowledge in science course*. Academia.edu. https://www.academia.edu/17866449/The_Effects_of_Brain_Based_Learning_on_Academic_Achievement_and_Retention_of_Knowledge_in_Science_Course?email_work_card=title

Pacheco, B. M., de Oliveira, V. H. R., Antunes, A. B. F., Pedro, S. D. de S., & Silva, D. (2023, July 11). *Does pre-training on brain-related tasks result in better deep-learning-based brain age biomarkers?* arXiv.org. https://arxiv.org/abs/2307.05241

Pantziara, M., & Philippou, G. N. (2014). Students' motivation in the mathematics classroom. revealing causes and consequences. *International Journal of Science and Mathematics Education*, *13*(S2), 385–411. https://doi.org/10.1007/s10763-013-9502-0

Parvin, P. (2012). *Ulric Neisser, the cognitive psychology pioneer, dies: Emory University: Atlantaga*. News. https://news.emory.edu/stories/2012/02/er_ulric_neisser_psychology/campus.html

Pillado, I. A., Futalan, M. C. Z., & Comighud, S. M. T. (2020, April 30). *Factors on memory retention: Effect to students' academic performance*. International Journal For Research In Mathematics And Statistics. https://gnpublication.org/index.php/ms/article/view/1277

Policy Corner: September 15, 2023. Brain Injury Association of America. (2023). https://www.biausa.org/public-affairs/media/policy-corner-september-15-2023

Posner, M. I., & Rothbart, M. K. (2023). How understanding and strengthening brain networks can contribute to elementary education. *Frontiers in Public Health*, *11*. https://doi.org/10.3389/fpubh.2023.1199571

Proctor, R. W., & Vu, K.-P. L. (2023). Historical overview of research on attention. *Attention:*

Selection and Control in Human Information Processing., 3–28. https://doi.org/10.1037/0000317-001

Rajput, J. S. (2016). *Indian education in times of global change* (1st ed., Vol. 1). Shipra Publications.

Ramakrishnan, J. (2016, January 19). *Brain-Based Learning Strategies*. Academia.edu. https://www.academia.edu/20384764/Brain_based_learning_strategies

Ramakrishnan, J., Avinashilingam University, & Annakodi, Dr. (2013). Brain-based learning strategies. *International Journal of Innovative Research and Studies*, 236–238. https://info.edmentum.com/rs/780-NRC-339/images/IJIRS%20%281%29.pdf

Ritter, F. E., Baxter, G. D., Kim, J. W., & Srinivasmurthy, S. (2013). Learning and retention. In J. D. Lee & A. Kirlik (Eds.), *The Oxford handbook of cognitive engineering* (pp. 125–142). Oxford University Press https://psycnet.apa.org/record/2013-01015-007

Sanatullova-Allison, E. (2014). Memory retention in second language acquisition and Instruction: Insights from literature and research. *IAFOR Journal of Language Learning*, *1*(1). https://doi.org/10.22492/ijll.1.1.02

Srinivasan , P. (2016, March 13). Psychology Experiment- Span of Attention. *prakasheducationblog*. September 10, 2023, https://prakasheducationblog.wordpress.com/2016/03/13/psychology-experiment-span-of-attention/

Sternberg, R. J., & Mio, J. S. (2007). *Cognitive psychology*. Thomson Wadsworth.

Tabesh, Y. (2017). Computational thinking: A 21st-century skill. *OLYMPIADS IN INFORMATICS*, *11*(2), 65–70. https://doi.org/10.15388/ioi.2017.special.10

The Agricultural Education Magazine. National Association of Agricultural Educators. (2006). https://www.naae.org/profdevelopment/magazine/

The computational thinking study. EU Science Hub. (n.d.). https://joint-research-centre.ec.europa.eu/computational-thinking-study_en

The Right of Children to Free and Compulsory Education Act, 2009 ... (n.d.-b). https://www.education.gov.in/sites/upload_files/mhrd/files/upload_document/RTE_Section_w

ise_rationale_rev_0.pdf

Toheed, L., Ali, A., & Jabeen, F. (2017, April 19). *The effect of mastery learning strategy on learning retention of secondary school students in the subject of Mathematics*. Journal of Education and Practice. https://www.iiste.org/Journals/index.php/JEP/article/view/37879

Wambach, D., Lamar, M., Swenson, R., Penney, D.L., Kaplan, E., Libon, D.J. (2011). Digit Span.In: Kreutzer, J.S., DeLuca, J., Caplan, B. (eds) Encyclopedia of Clinical Neuropsychology. Springer, New York, NY. https://doi.org/10.1007/978-0-387-79948-3_1288

Wechsler Intelligence Scale for children - memory for digit span. Wechsler Intelligence Scale for Children - Memory for Digit Span | National Longitudinal Surveys. (n.d.). https://www.nlsinfo.org/content/cohorts/nlsy79-children/topical-guide/assessments/wechsler-intelligence-scale-children

Westphal, J. (2022, May 31). *Descartes and the discovery of the mind-body problem*. The MIT Press Reader. https://thereader.mitpress.mit.edu/discovery-mind-body-problem/

Williams, J. M., Williams, K., & Gillard, E. (1991). The Memory Assessment Scales (MAS): A new clinical memory battery. *Archives of Clinical Neuropsychology*, *6*(3), 234–235. https://doi.org/10.1093/arclin/6.3.234a

Wing, J. M. (2006). *Communications of the ACM*, *49*(6). https://doi.org/10.1145/1132469